Listing of Amended Claims

The listing of claims below replaces all prior versions and listings of claims.

Claim 1 (canceled):

Claim 2 (canceled):

Claim 3 (currently amended) ~~The method of claim 2, wherein decomposing each of the spatial objects into subspaces comprises decomposing each of the spatial objects into z-cells according to z-ordering.~~ A method for use in a computer implemented database system, comprising:

storing plural tables each containing spatial objects;

decomposing each of the spatial objects into z-cell subspaces according to z-ordering;

distributing the subspaces across plural partitions; and

performing, in parallel in the plural partitions, a join of the spatial objects of the plural tables.

Claim 4 (original): The method of claim 3, wherein storing the plural tables containing spatial objects comprises storing the sets of z-cells, each set representing a spatial object.

Claim 5 (original): The method of claim 4, wherein storing the sets of z-cells comprises storing the sets at plural z-levels.

Claim 6 (original): The method of claim 5, further comprising identifying at least one of the plural levels as an optimal partition level at which partitioning of the spatial objects occurs.

Claim 7 (original): The method of claim 6, wherein identifying the optimal partition level is based on a cost-based analysis.

Claim 8 (original): The method of claim 7, further comprising performing the cost-based analysis by accumulating a count of a number of z-cells at each level.

Claim 9 (original): The method of claim 5, further comprising identifying at least one of the plural z-levels as an optimal join level at which a join of spatial objects of plural tables occurs.

Claim 10 (original): The method of claim 9, further comprising using a cost-based analysis to identify the optimal join level.

Claim 11 (original): The method of claim 9, further comprising determining, based on the z-level a given z-cell of a spatial object is at, whether to duplicate the given z-cell or to enumerate the given z-cell into z-cells at a lower level.

Claim 12 (original): The method of claim 11, further comprising duplicating the given z-cell to the plural partitions if the z-level of the given z-cell is at least a predetermined number of z-levels above the optimal join level.

Claim 13 (original): The method of claim 12, further comprising enumerating the given z-cell if the z-level of the given z-cell is less than the predetermined number of levels above the optimal join level.

Claim 14 (original): The method of claim 13, wherein enumerating the given z-cell comprises dividing the given z-cell, if the z-level is greater than the optimal join level, the given z-cell into corresponding z-cells at the optimal join level, the method further comprising redistributing the z-cells at the optimal join level.

Claim 15 (original): The method of claim 14, further comprising determining, if the z-level of the given z-cell is less than the optimal join level, the ancestor z-cell at the

optimal join level containing the given z-cell, the method further comprising redistributing the z-cell at the optimal join level.

Claim 16 (original): The method of claim 15, wherein performing the join of the spatial objects comprises performing joins of z-cells based on comparisons of intervals of z-cells at the optimal join level representing the spatial objects on each partition.

Claim 17 (original): The method of claim 16, further comprising performing false hit avoidance to avoid false hits due to comparisons performed at the optimal join level.

Claim 18 (original): The method of claim 16, further comprising performing duplicate avoidance.

Claim19 (original): The method of claim 16, further comprising defining a z-cell less than the predetermined number of levels above the optimal join level, at the optimal join level, or below the optimal join level as having a zero-length interval,

the method further comprising optimizing the join for zero-length interval z-cells.

Claim 20 (original): The method of claim 16, further comprising defining a z-cell at least at the predetermined number of levels above the optimal join level as having a non-zero-length interval containing z-cells at the optimal join level.

Claim 21 (currently amended): The method of claim [[1]]3, further comprising reducing skew in dividing the spatial objects across multiple partitions, and reducing duplication of objects to the multiple partitions to enhance efficient parallel spatial join.

Claim 22 (currently amended): The method of claim [[1]]3, wherein dividing the spatial objects across plural partitions is based on characteristics of the spatial objects instead of characteristics of the tables.

Claim 23 (original): The method of claim 22, further comprising identifying an optimal partition level, wherein dividing the spatial objects comprises performing one of duplication, enumeration, and redistribution based on a relationship of a spatial object to the optimal partition level.

Claim 24 (canceled)

Claim 25 (currently amended): ~~The article of claim 24, wherein the spatial objects are represented by z-cells at plural z-levels, wherein the instructions when executed cause the database system to further define one of the z-levels as an optimal join level, wherein performing the join is performed using z-cells at the optimal join level.~~
An article comprising at least one computer readable storage medium containing instructions that when executed by a computer cause a database system to:

represent the spatial objects as z-cells in z-ordered space at plural z-levels;

define one of the z-levels as an optimal join level;

distribute the z-cells representing the spatial objects of tables across plural partitions; and

perform a join of the distributed z-cells in each partition at the optimal join level.

Claim 26 (original): The article of claim 25, wherein the instructions when executed cause the database system to further:

identify whether a given z-cell is at least a predetermined number of z-levels above the optimal join level; and

duplicate the given z-cell to the plural partitions if the given z-cell is at least the predetermined number of z-levels above the optimal join level.

Claim 27 (original): The article of claim 26, wherein the instructions when executed cause the database system to further:

enumerate the given z-cell into z-cells at the optimal join level if the given z-cell is less than the predetermined number of z-levels above the optimal join level; and

distribute the z-cells at the optimal join level across the plural partitions.

Claim 28 (original): The article of claim 27, wherein the instructions when executed cause the database system to further:

identify an ancestor z-cell at the optimal join level containing the given z-cell if the given z-cell is at a z-level less than the optimal join level.

Claim 29 (currently amended): The article of claim [[24]]<u>25</u>, wherein the instructions when executed cause the database system to further identify one of the z-levels as an optimal join level and one of the z-levels as an optimal partition level,

wherein performing the join is performed at the optimal join level, and

wherein distributing the z-cells representing the spatial objects is based on a relationship of each spatial object to the optimal partition level.

Claim 30 (original): The article of claim 29, wherein the instructions when executed cause the database system to identify the optimal join level and the optimal partition level based on a cost analysis.

Claim 31 (currently amended): The article of claim [[24]]<u>25</u>, wherein the instructions when executed cause the database system to further perform false hit avoidance and duplicate avoidance.

Claim 32 (original): The article of claim 31, wherein the instructions when executed cause the database system to further:

define certain of the z-cells as having a zero-length interval; and

optimize the join for zero-length interval z-cells.

Claim 33 (canceled):

Claim 34 (currently amended): ~~The database system of claim 33, wherein the controller is adapted to represent the spatial objects in z-cells in a z-ordered space.~~

A computer implemented database system comprising:

a storage subsystem to store tables containing spatial objects;

a plurality of access modules to manage parallel access of respective portions of the storage subsystem; and

a controller for decomposing each of the spatial objects into z-cell subspaces according to z-ordering and for managing a parallel join of the spatial objects by the plurality of access modules.

Claim 35 (canceled):

Claim 36 (currently amended): The database system of claim [[35]]34, wherein the z-cells representing the spatial objects are in plural z-levels, the controller ~~being adapted to~~ identif[[y]]ies one of the plural z-levels as an optimal join level, and

the controller ~~adapted to~~ performs the parallel join of the z-cells at the optimal join level.

Claim 37 (currently amended): The database system of claim 36, wherein the controller ~~is adapted to~~:

identif[[y]]ies one of the z-levels as an optimal partition level; and

distributes each spatial object across the plural access modules according to a relationship of the spatial object to the optimal partition level.

Claim 38 (currently amended): The database system of claim [[35]]34, wherein the controller ~~is adapted to~~ distributes z-cells of the spatial objects across the access modules.

Claim 39 (currently amended): The database system of claim 38, wherein the controller ~~is adapted to~~ distributes the z-cells by performing one of duplication, enumeration, and redistribution of each spatial object.